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An Improved Wireless Sensor Network Mode based on Complex Network Theory

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Abstract

This paper proposes an improved scale-free network model this paper introduces the traditional scale-free network theory and analysis methods of more appropriate wireless sensor network, it will be more close to the real wireless sensor network statement. The improved model is based on the complex network theory prove research more suitable to the wireless sensor network.

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Keywords: Wireless sensor network; Complex network theory; Scale-free network

1. Introduction

In recent years, the wireless sensor network attracted more and more relevant researchers for its advantages. The sensor node is usually low power consumption, disposable. Complete the original network will be destroyed and the other nodes burden will have more business data transmission of energy if some node runs out. The key issue is the balance of wireless sensor network study the influence of the sensor node energy consumption and reduces the sensor node random failure or random attack, to the whole network of sensor nodes [1].

The complex network theory has been put forward for the first time since barabasi, and Albert in 1998, but the complex network theory and methods used in wireless sensor network of research and development of rare serious slow progress.

Improved Scale-Free Model For WSN

In response to these points, based on the traditional scale-free model, this paper has made the following improvements in the process of model establishment:

(1) A number of studies, many complex network not only the result of the internal force of nature, but also the result from external forces, they should not be ignored, form a whole complex network. Node

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failed not only can happen node energy consumption or random attack, they are in sensor networks work progress, but happened outside forces, such as by nature, when deployed. In this paper, the stochastic damage mechanism of small probability increased the formation of sensor networks.

(2) In the two nodes and Internet network to connect directly to the other party and their connection never limited by their true position, a wireless sensor network nodes connected to the other two kinds of ways of making each node has the biggest length limit their communication radius. Ensure that the whole network of rare, must be a minimum length limit their communication radius. In this paper, the communication radius length limitation of sensor nodes is proposed based on the improved model.

2. Description of the improved algorithm

The specific algorithm of the improved model formation is described as follows:

(1) A given region (assumed to be square) is divided into HS*HS big squares (named as BS);

(2) Each BS (assumed to be square) is divided into LS*LS small squares (named as SS), and each SS can have only one node in its coverage region;

(3) m_0 backbone nodes are initially generated as a random graph, and then a new node will be added to the network to connect the existing m nodes with m edges at each time interval. (m<m0, m is a quantity parameter);

(4) The newly generated node v, has a certain probability of P_e to be damaged directly so that it will never be connected with any existing nodes;

(5) The newly generated node v connects with the existing node i, which obeyes dependent-preference rule and is surely limited by the degree of the certain saturation value k_{imax};

(6) The distance d_{iv} between the newly generated node v connects and the existing node i shall be shorter than the maximum d max of the communication radius of sensor nodes.

Above all, the probability that the existing node i will be connected with the newly generated node v can be shown as follows:

$$\pi_1 = \frac{k_i}{\sum_{j=1}^{N} k_j - nk_{i\max}} \bullet P\{d_{iv} \le d_{\max}\} \bullet (1 - P_e) \tag{1}$$

In order to compute it conveniently, here assumed that few nodes had reached the degree of saturation value k_{imax}. That is, n is very minimal in Eqs.(1) so that it can be ignored here. And in Eqs.(1), $P\{d_{iv} \le d_{\max}\} \bullet (1 - P_e)$ can be regarded as a constant parameter, so we have $P\{d_{iv} \le d_{\max}\} \bullet (1 - P_e)$ =a, and Eqs.(1) can be rewritten as:

$$\pi_1 = \frac{ak_i}{\sum_{j=1}^{N} k_j} \qquad N = m_0 + t - 1 \tag{2}$$

With The varying rate with time of ki , we get:

$$\frac{\partial k_i}{\partial t} = m\pi_1 = \frac{amk_i}{\sum_{j=1}^{m_0+t+1} k_j - nk_{i\max}} = \frac{amk_i}{2mt - m} \tag{3}$$

When $t \to \infty, \frac{\partial k_i}{\partial t} = \frac{ak_i}{2t} = \frac{k_i}{\frac{2}{a}t}$. According to the initial condition: $k_i(t_i) = m$, we get the solution:

$$k_i(t) = m\left(\frac{t}{t_i}\right)^{\beta}, \beta = \frac{2}{a} \tag{4}$$

The probability that the degree of node i is smaller than k is:

$$P\{k_i(t) < k\} = P\{t_i > \frac{m^{1/\beta}t}{k^{1/\beta}}\} \tag{5}$$

The time interval when each newly generated node connected into the network is equal, so that probability density of t_i is a constant parameter:

$$P(t_i) = \frac{1}{m_0 + t}$$

we replace it into Eqs. (5), then we get:

$$\begin{aligned} P\{k_i(t) < k\} &= P\{t_i > \frac{m^{1/\beta}t}{k^{1/\beta}}\} - P\{t_i \le \frac{m^{1/\beta}t}{k^{1/\beta}}\} \\ &= 1 - \sum_{t_i=1}^{\frac{m^{1/\beta}t}{k^{1/\beta}}} P(t_i) = 1 - \frac{m^{1/\beta}t}{k^{1/\beta}(t+m_0)} \end{aligned} \tag{6}$$

So we get:

$$P(k) = \frac{\partial P\{k_i(t) < k\}}{\partial k} = \frac{2m^{1/\beta}t}{(t+m_0)} \cdot \frac{1}{k^{1/\beta}} \tag{7}$$

When $t \to \infty$, we get:

$$P(k) = 2m^2 k^{-r} \tag{8}$$

In which $\gamma = 1 + \frac{1}{\beta} = 1 + \frac{2}{a}$ and the degree distribution we get and the degree distribution of traditional scale-free network are similar. Approximately, it has nothing to do with the time parameter t and the quantity of edges m generated at each time interval.

$P\{d_{iv} \le d_{\max}\}$ could be calculated by the maxinum restriction d_{max} on communication radius of each sensor node and the area of the entire coverage region S, that is $P\{d_{iv} \le d_{\max}\} = \frac{\pi d^2}{S}$ Then we we replace $P\{d_{iv} \le d_{\max}\} = \frac{\pi d^2}{S}$ and a= $P\{d_{iv} \le d_{\max}\} \bullet (1 - P_e)$ into Eqs. (5), and eventually we get:

$$P(k) = 2m^2 k^{-1-\frac{2}{a}} = 2m^2 k^{-1-\frac{2S}{(1-p_e)\bullet \pi d^2}} \tag{9}$$

3. Simulation

This paper used Java GUI mode of BRITE topology generator to generate the topology, and parameter settings were as follows:

(1) N=5000

N means the quantity of the sensor nodes at the end of the topology generation.

(2) m = m0= 1

m means the quantity of the new generated edges by the new generated node at each time interval.

(3) HS=500

HS means the given region was divided into HS*HS big squares.

(4) LS=50

LS means each big square was divided into LS*LS small squares.

(5) d_{min} =10

dmin is the mininum restriction on communication radius of each sensor node.

(6) d_{max} =128

dmax is the maxinum restriction on communication radius of each sensor node.

(7) PC=1

PC means wether preferential connectivity or not.

(8) IG=1

IG means wether incremental grouth or not.

(9) P =0.01, m=1

This means that any newly generated node has 1% chance to be node failure and the newly generated node if normal only connect with one existing node.

Then we got each degree of the sensor network nodes from BRITE topology generator. To analyze the degree distribution, we use Matlab to calculate datas and draw graph. As can easily be seen from Fig. 1, the distribution of degree k subjected approximately to Power-Law distribution. However, the value of γ is no longer between 2 and 3, but a very large value, which is caused by the random damage probability Pe to new generated nodes when deployed and the maxinum of communication radius d max of each sensor node. It can be easily seen that the slope of P(k) is very steep and P(k) rears up because sensor node has a limited degree of saturation value by 180. The existence of 0 degree nodes is result from the random damage to new generated nodes when deployed.

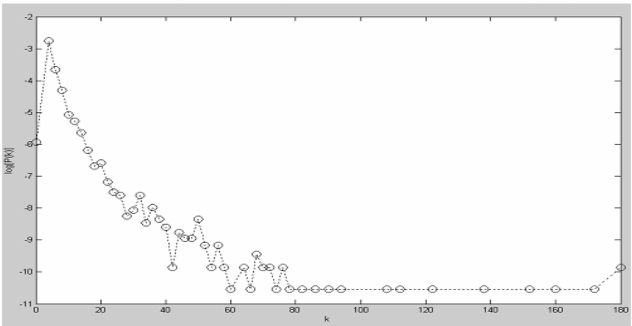

Fig. 1 Degree distribution of Improved Model

Compared with the traditional degrees from the distribution of scale-free networks conclusion shown in figure 2, this paper puts forward the formation rules produced degree distribution low value in figure 1 shows is that there are some node is 0 degrees chart 1 shows is on the left of the stochastic damage rule; On the right shown in figure 1, not the number of node than higher degree, and some of the node to a higher degree of degrees than quantity for 180 people.

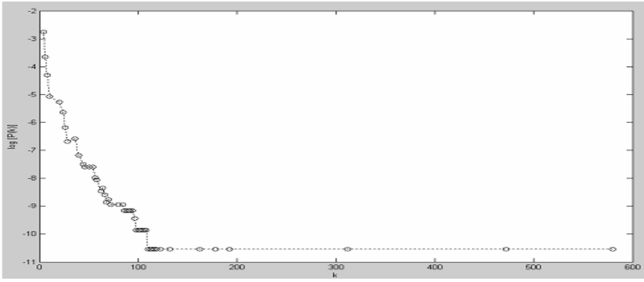

Fig. 2 Degree distribution of traditional Scale-free Model

4. Conclusion

This paper introduces the design of a new generation of node random damage when deployed, considering the kind of transmission wireless sensor network, and put forward a kind of maximum each sensor node communication radius; In order to improve the work efficiency, saving energy and reducing consumption and maintain the whole network of rags, this article also added a minimum limit each sensor node communication radius of the improved model, to balance the whole network of energy consumption, and put forward a limited degree of saturation value for each sensor node.

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